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A RESOURCE BOOK OF KEY TEACHER DEMONSTRATIONS FOR HIGH SCHOOL PHYSICAL SCIENCE

A Field Report

Presented to

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In Partial Fulfillment

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Master of Science in Education

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by

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CHAPTER I

INTRODUCTION

I. THE PROBLEM

The modern high school has the responsibility of offering three levels of science education: (1) The traditional academic science courses for the development of professional scientists; (2) The technical science offered in trade and vocational fields to develop science technicians and mechanics; (3) science courses designed to develop intelligent, practical, scientific-minded citizens.

With reference to the third type of course, there seems to be a need for the inclusion in the high school curriculum of an additional science course. This course could be taught with the goal of teaching non-college preparatory students basic scientific principles that govern sources of scientific devices necessary for the continuation of our high standard of living.

A physical science course geared to the needs and abilities of non-college bound students would make available a source of practical scientific principles. Many students have neither the interest or the ability to successfully meet the requirements of high school physics and chemistry. These students are, however, required to take one year of science for high school graduation. An alternate science, physical science, would enable these students to profitably meet this requirement.

Purpose of the study. The purpose of the study was to prepare directions for "Key Teacher Demonstrations" for a high school physical science class. A total of thirty-two demonstrations were included, four for each of the eight units of the course.

II. THE PHYSICAL SCIENCE COURSE

In assuming the educational responsibility for the community, the public high school has the job of educating nearly all the youth. The high school owes the best education it can give to those students having high scholastic ability. This same institution owes the best education available to students having less academic ability. This group often becomes the victim of the curriculum directed more specifically to the higher-achieving group. Their future success in the factory, the store, the business office, the service job, on the farm, and in the home, depends on the development of a curriculum which meets their specific needs.[1]

Secondary school science is, therefore, concerned

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[1] E. P. Wigner, Physical Science and Human Values, (Princeton: Princeton University Press, 1947), p. 4.

primarily with the general education of all young people, including those who do not go to college, as well as those who do. College preparatory courses should be considered in their proper perspective in relation to the total curriculum. For this reason, there is a real need for the inclusion of a high school physical science course directed toward the non-college bound student.[1]

Modern physical science is a course for the general education of students who require a course that is simple and interesting, but which gives them some knowledge of the practical aspect of science.[2] The recent change in the course content of high school physics from the traditional "mechanics" approach to the Physical Science Study Committee's "theory" approach has made it increasingly difficult for the below average student to have even moderate success in this subject. A course should be offered those students that includes only the barest minimum of theory which is essential to an understanding of science as organized knowledge.[3] Students in this category often have only the minimum amount of mathematics for graduation. This fact should

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[1]J. S. Richardson and G. P. Cahoon, Methods and Materials for Teaching General and Physical Science, (New York: McGraw Hill Book Co., 1951), p. 16.

[2]William Brooks and George Trachey, Modern Physical Science, (New York: Holt and Company, 1959),p.v.

[3]Ibid.

be considered as a course of study is developed.

In developing a course of study, specific objectives should be considered. As a teacher of high school physics and chemistry for the past nine years, this writer has developed an increasing awareness of the need for physical science courses. This interest has prompted the development of a course of study that includes the following objectives of the teaching of physical science:

OBJECTIVES OF PHYSICAL SCIENCE

1. To develop a knowledge of certain elementary laws and generalizations in the field of science helpful in understanding man's environment.
2. To develop an understanding and ability to apply the scientific method in the solution of problem.
3. To develop an understanding of science equipment and ability to use it.
4. To appreciate the contributions of science and scientists to civilization.
5. To provide training which will enable pupils to become discriminating consumers.
6. To develop the ability to read, understand and use an accurate and appropriate scientific vocabulary in written and oral expression.

7. To develop an objective attitude toward ideas and social problems that contribute to human welfare.

8. To understand and practice the conservation of natural resources.

9. To help the pupil establish vocational and avocational interests through his knowledge of science.

These objectives may be reached through the teaching of eight units that are most often included in high school physical science text books. These units are:

1. The Atmosphere
2. Water and Its Use
3. Sound
4. The Sources and Control of Heat
5. Our Use and Control of Light
6. Electricity and Magnetism
7. The Place Our Earth Occupies Among the Heavenly Bodies
8. Weather

III. THE USE OF DEMONSTRATIONS IN TEACHING HIGH SCHOOL PHYSICAL SCIENCE

There is a place--and usually it is a neglected place--for teacher demonstrations in the teaching of science.[1] Verbal descriptions of scientific phenomena and statements of scientific principles need to be supported by realistic

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[1] R. Will Burnett, Teaching Science in the Secondary School, (New York: Rinehart & Company, 1951), p. 197.

experiences, if the student is to grasp the full impact of the scientific learnings.

Pupils vary widely in their ability to read, to comprehend what they have read, and to visualize and recall this material when necessary. Those students studying physical science have a variety of backgrounds, as well as great variations in their abilities to grasp new ideas. The most immediate problem is that of reading. Teachers can assist the poor reader by providing ample opportunity for the learner to observe and participate in well-chosen teacher demonstrations. The visual approach is almost a necessity, if the poor reader is to gain much from science.

The teacher has a mature understanding of the goal that he wishes to reach, and also he has the experience of manipulating the scientific equipment so that the students feel secure in the conclusions drawn.[1] An experienced teacher can point out and emphasize important points and interpret and explain others as the demonstration progresses.

In an age when there are so many areas to be taught within a given span of time, a teacher must be very selective of the material presented to his students. A teacher must determine the most important learnings to present and then

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[1]R. Will Burnett, Teaching Science in the Secondary School, (New York: Rinehart and Company, 1951), p. 200.

select the teaching method best suited for this presentation. The classroom demonstration is a technique often employed.

Like most other effective techniques or procedures in science teaching---educational films,laboratory work, direct study, discussion demonstrations may be used for a variety of purposes. These purposes would include: (1) motivation, (2) explanation of a principle or its application, (3) preview of a unit of work, (4) provisions for individual students' needs or interests, (5) example of a skill or technique, (6) review of a unit or area of learning, (7) evaluation of a student's understanding.[1]

IV. PROCEDURE

There are many sources of teacher demonstrations available. These would include: suggestions from the text book currently being used, as well as other associated text books; science teacher journals; and the reports concerning the success of other science teachers. Locating appropriate demonstrations for each particular learning objective often proves to be a difficult, time-consuming process. It is for this reason that the demonstrations in this resource booklet have been carefully selected and screened as those which will

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[1] John Richardson, Methods and Materials for Teaching General and Physical Science, (New York: McGraw-Hill Book Co., Inc., 1951), p. 16.

effectively augment the fundamental scientific principles concerning the eight units mentioned above. These demonstrations were selected on the basis of their ability to fulfill the following teaching objectives:

1. Set up a problem.
2. Illustrate a point.
3. Help solve a problem.
4. Review a unit.
5. Serve as a climax of a unit.[1]

Also used as a guide for consideration of demonstrations are criteria for a good teacher demonstration, which, according to John Richardson, would include:

1. The demonstration should be tried previously.
2. The purpose of the demonstration is clear.
3. The demonstration is visible to all students.
4. The apparatus used is as simple as possible.
5. The demonstration fulfills the teaching objective desired.[2]

The demonstrations in this report are divided into eight major divisions, each division representing an im-

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[1] Walter A. Collette, Teaching in Today's Secondary Schools, (Boston: Allyn and Bacon, Inc., 1959), p. 128.

[2] John Richardson, Methods and Materials for Teaching General and Physical Science, (New York: McGraw-Hill Book Co., Inc., 1951), p. 16.

portant unit included in a physical science course. Four key demonstrations are included to illustrate specific scientific principles concerning these major divisions. Each demonstration is broken down into five smaller sub-divisions. These sub-divisions are: (1) Objective; (2) Material; (3) Method; (4) Observation; (5) Conclusion. This sub-division of individual demonstration increases the clarity of presentation.

The demonstrations and the sub-divisions of the demonstrations have evolved as a result of trial and error, selecting and rejecting, adapting and modifying during nine years of teaching chemistry and physics by the writer.

V. ORGANIZATION OF THE FIELD REPORT

This resource booklet is divided into eight units. These units encompass areas of everyday experiences that can be understood through a knowledge of basic scientific principles. This knowledge will provide a student a more secure position in the world about him, and will increase his interest in his own responsibilities to that world. The units to be covered are:

1. The Atmosphere
2. Water and its Uses
3. Sound
4. The Sources and Control of Heat

5. Our Use and Control of Light

6. Electricity and Magnetism

7. The Place Our Earth Occupies Among the Heavenly Bodies

8. Weather

The body of the report will consist of four demonstrations for each of the eight units. Each demonstration will include:

1. The objectives of the demonstration.

2. The materials needed for the demonstration.

3. The method of presenting the demonstration.

4. The observations students would most likely be able to make.

5. The conclusions or generalizations that should be developed through discussion of the demonstration.

CHAPTER II

THE DEMONSTRATIONS

The demonstrations presented in this chapter are arranged under eight sub-divisions--the sub-divisions of the physical science course. There are four demonstrations under each sub-division.

These sub-divisions are:

1. The Atmosphere
2. Water and its Uses
3. Sound
4. The Sources and Control of Heat
5. Our Use and Control of Light
6. Electricity and Magnetism
7. The Place Our Earth Occupies Among the Heavenly Bodies
8. Weather

I. THE ATMOSPHERE

We live at the bottom of a great, unbounded ocean, the atmosphere. It surrounds the more solid parts of the earth, the land and water, but it is just as truly a part of the earth as they are. When we are not moving, and when no winds blow, we are hardly conscious of its existence. However, it is all about us, producing remarkable effects.

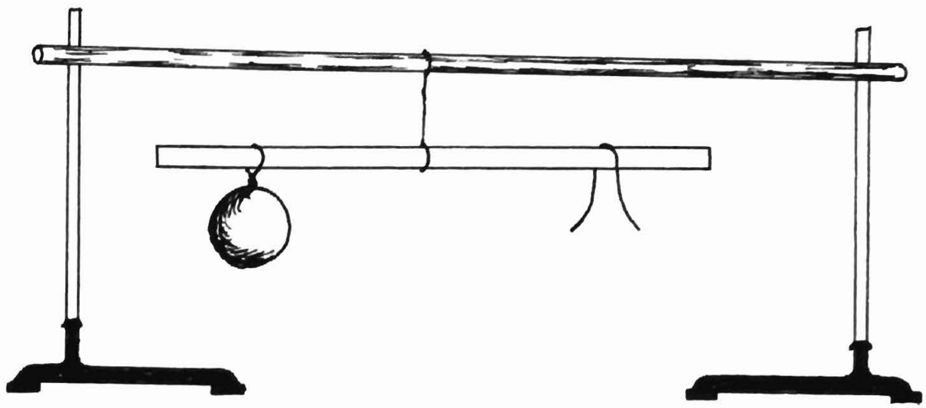
The atmosphere is a mixture of gases. Nitrogen makes up almost four-fifths of the atmosphere, and oxygen a little more than one-fifth. There are also small quantities of other gases, including argon, neon, helium, krypton, xenon, carbon dioxide, hydrogen and ozone, which is a form of oxygen. We also find a variable amount of water vapor that has evaporated from the oceans, lakes and rivers into the atmosphere. The earth holds all these gases to it by the pull of its gravitational attraction; otherwise they would drift off into space.

The purpose of the demonstrations for this unit is to develop understandings concerning the fact that air has weight, that air has pressure, the laws governing the compressibility and expansibility of air, and the behavior of air in motion.

Demonstration: Air Has Weight

Objective. To demonstrate that air has weight.

Materials. Yard stick with a one-eighth inch hole drilled through the smallest dimension, 18" from the end; toy balloon; a piece of number eighteen wire; four feet of string; a cross bar to use as a support. A drawing of this apparatus is shown on the next page.



Method. Tie a string from a cross bar. Tie the yard stick to the string through one-eighth inch hole. Tie uninflated balloon loosely to a small piece of string located at one end of the yard stick. Place a number eighteen wire in the form of a loop over the opposite end of the yard stick and move as a rider along the yard stick until it comes to balance. Now remove the balloon, being careful not to move the position of the attaching string on the yard stick. A student assistant should be available at this time to hold the yard stick level so that the counter-balancing rider will not move from its point of balance. Inflate the toy balloon and fasten it securely to attached string.

Observation. The side of the homemade beam balance on the balloon side will drop two or three inches.

The conclusion or generalizations that should be developed through discussion. Air has weight. At sea level, one cubic foot of air weighs 1.25 ounces, and one cubic yard weighs a little more than two pounds. The air in a school room thirty feet long and twenty-four feet wide, with a fourteen foot ceiling, weight nearly 800 pounds.

Air is the popular standard for comparing weights of other gases. Giving air as the standard weight of one, often called specific gravity, gases lighter than air would have a specific gravity of less than one, gases heavier than air would have a specific gravity greater than one. Several gases are less dense than air, including nitrogen, ammonia and carbon monoxide, but many gases are considerably denser than air, such as carbon dioxide.

A follow-up on this demonstration would include the use of other gases in the balloon and compare the change in balance to determine if they weigh more or less than air.

Demonstration: Compressibility and Expansibility of Air

Objective. To show that air can be compressed, and that air will expand.

Materials. Pop bottle; glass tubing; rubber tubing; hole stopper; water vacuum pump; bell jar; sealing wax; toy balloon.

Method. Part I. Secure a large, narrow-necked bottle such as one in which soda water comes. Place a one-hole stopper in the bottle. Through the stopper put a ten centimeter length of glass tube which has been drawn to a jet on the outside end. With a short length of rubber tube attach a length of glass tube that will extend nearly to the bottom of the bottle. Fill the bottle about half full of water. Insert the stopper firmly and hold it in with your fingers. Next, blow hard into the bottle; and when you release the pressure, point the bottle away from you.[1]

Part II. Place a very small amount of air in a toy balloon and place under a bell jar and remove the air that surrounds the balloon. As the air is removed from the bell jar, pressure on the outside of the balloon is being reduced. The gas inside expands and increases the volume of the balloon decidedly. If air is then let back into the bell jar, the balloon will shrink to its former size.

Observation. Part I. As air is blown into the bottle, bubbles of air pass through the water, and, added to the air that is already in the bottle, causes compression of the air. When pressure is removed from the tube, this compressed air pushes on the water and forces it, with much pressure, out of the jet.

Part II. The balloon under reduced external pressure increased in size. With the return of normal atmospheric

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[1] UNESCO, UNESCO Source Book for Science Teaching, (Netherlands: UNESCO, 1956), p. 26.

pressure, the balloon returned to its normal size, thus showing that air can expand and contract.

<u>Conclusions or Generalizations that should be developed through discussion</u>. Air can be compressed or expanded. The pressure of this air controls the size of balloons. Pneumatic appliances use differences in air pressure for their operation. A list of pneumatic appliances would include: the pneumatic bicycle and automobile tire; force water pump (which insures a steady stream of water); the door check which prevents slamming; the ordinary bicycle tire compression pump; air tanks used to operate the aqua-lungs of skin divers.

Demonstration: Air Exerts Pressure

<u>Objective</u>. To demonstrate that air has pressure.

<u>Materials</u>. A can that has a tightly fitting cover or an opening with a screw cap; ring stand; bunsen burner; matches, a large container of cold water (This container should be preferrably made of glass so that students could see); a bicycle pump with some kind of weight holder attached to the handle; weights; cross bar; a glass tube (closed at one end and at least 31 inches long); a pound of mercury; a small glass or beaker; a meter stick.

Method. Part I. Place a small amount of water in the can. Stand it on the ring stand and heat with the cover removed until the water boils vigorously. While the boiling is still in progress, close the vessel tightly, quickly place it in the container of cold water to condense the steam within. Outside air pressure does the rest. Actually, the can may be cooled by merely allowing it to stand for a few minutes, or by pouring a small amount of water on it, or by placing a damp cloth around the can.

> Part II. A bicycle pump with the washers reversed on the piston can be used to measure atmospheric pressure. The area of cross section of the pump barrel can be calculated or measured with squared paper. The pressure of the air can then be calculated in pounds per square inch. The weight supported by the upthrust of atmospheric pressure is found by hanging various loads from a hook, screwed into a wooden plug fitted into the pump handle.[1]

Part III. Fill the 31 inch glass tube that is closed at one end with mercury, and with your finger placed over the open end, invert the opening into a glass that is partly filled with mercury. Remove your finger and notice that the mercury drops in the tube a little and then stops at about 29 inches above the level of the mercury in the glass dish.

Observation. Part I. Air pressure collapsed the

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[1] Ibid., p. 27.

can. Part II. It took about fourteen pounds of weight per square inch to pull down the piston of the air pump. Part III. A difference of 29 inches of mercury is shown in the homemade barometer.

Conclusions or generalizations that should be developed through discussion. The existence of atmospheric pressure can be shown by removing the air from one side of an exposed surface. Air pressure exerts a force upon all surfaces in all directions. Pneumatic appliances use differences in air pressure for their operation. Air pressure at sea level exerts a force of 14.7 pounds per square inch. Air always tries to move from an area of high pressure to an area of low pressure. Thus it may do work. Atmospheric pressure at sea level will support a column of mercury 30 inches high. Air has pressure because it has weight. Altitude can be determined by measuring air pressure. Air pressure is measured to predict weather.

Demonstration: Air in Action

Objective. To provide illustrations of Bernoulli's principle, thus enabling students to understand the force that keeps an airplane aloft.

Materials. Venturi meter; wooden spool; straight pin; a small square of paper 2" x 2"; a strip of paper 1" x 5"; a pencil; two ping pong balls; two pieces of thread three feet long; cross arm support; soda straw.

Method. Part I. Place colored water in the manometer of the Venturi tube. Raise the tube to mouth level and blow through the tube, noting the level of the liquid in the manometer tube. As a point of explanation before continuing the remainder of the demonstration, the instructor should develop Bernoulli's principle; This explanation should be developed around Newton's laws of motion. Simply stated, since the air is accelerated when it enters the narrow section of the Venturi tube, there must be a force that makes it move faster. That force can be due only to the pressure difference between the wider part of the tube and the narrower part of the tube. Thus, in the narrower part of the tube the pressure is lower because this pressure has been converted into the higher velocity (kinetic energy).

Part II. Hang two ping pong balls, to which a three foot piece of string has been glued, from the arm support, about one inch apart. With a soda straw, direct a steady stream of air between the two balls. The harder the air is blown, the better.

<u>Observation</u>. Part I. The level of the colored water in the manometer section which connects to the narrowest part of the Venturi tube rises. Since the air is accelerated when it enters the narrow section there is a force that make it move faster. That force is due to the pressure difference between the wider part of the tube and the narrower part of the tube. In the narrower part of the tube the pressure is lower because this pressure has been converted into higher velocity (kinetic energy).

Part II. Blowing makes the paper cling to the spool. The explanation is that between the card and the flat top of the spool the air is moving rapidly outward, while the air in contact with the outer surface of the card is at rest. This results in a force holding the card and spool together. The pressure of the air molecules has been converted into kinetic energy.

Part III. Blowing across the strip of paper causes the paper to move upward, thus illustrating lift. The molecules of air on the top side of the paper are moved across the upper surface before they have an opportunity to collide with this surface. The molecules on the lower surface are stationary, or at least they are moving more slowly than those on the upper surface, thus giving the molecules an opportunity to collide with the lower surface.

This unbalance of molecular force causes a pressure on the lower surface, considered as an upward thrust.

Part IV. As air is blown between the ping pong balls, the balls come together, rather than being blown apart. This is also due to an unbalanced molecular force.

The conclusion or generalizations that should be developed through discussion. Air pressure exerted perpendicular to the direction in which air is flowing decreases as the speed of the air increases, thus producing lift on the air plane wing. Simply stated, fast moving air has less pressure than slow moving air.

II. WATER AND ITS USES

Next to air, water is the most necessary part of our environment. Without water we could live about four days, after using up that supply which the body naturally carries. We have learned from history that rivers and other bodies of water were instrumental in the development of civilization. Adequate supplies of clean, pure water is necessary for the continuation of our present standard of living. This very year, President Kennedy has indicated the necessity for developing new sources of water for our communities if we hope to continue this standard of living.

It is of vital importance that students understand the need and problems associated with the conservation of water, one of our most important resources. Some characteristics of water that should be developed in a consumer type physical science course are: the composition of water; water pressure; a definition of "hard" water and an understanding of how it can be softened; and the buoyancy of water.

Demonstration: The Composition of Water

Objective. To show how an electric current may be used to separate the two gases which make up water.

Materials. A six volt storage battery, or a rectifier with an output of six volts; two large test tubes; three 18" lengths of eighteen gauge insulated copper wire; a knife switch for opening and closing the circuit; two platinum electrodes or two carbon electrodes made from the carbon poles found in a small dry cell battery; a small quantity of dilute sulfuric acid; distilled water; and a shallow dish.

Method. The test tubes should be filled with water and inverted in the shallow dish containing water. Set the platinum terminals in each test tube which is then properly supported by the ring stand and clamp. Connect the electrodes with the storage battery with a knife switch inserted in the circuit. Add a small amount of electrolyte, sulfuric acid, to the water in the shallow dish, and you are ready for observation of your demonstration. Close the circuit, and watch the test tubes with care.

Observation. Small bubbles of gas are formed on the electrodes and rise to the top of the tube, thus displacing water from the test tubes. The quantity of gas from the negative electrode collects twice as fast as on the positive pole. Now test the tube with the smallest amount of collected gas with a glowing wood splint. The splint bursts into flame, indicating the presence of oxygen. Test the other tube containing the largest amount of gas with a burning splint. The gas bursts into flame, indicating the presence of hydrogen.

The conclusions or generalizations that should be developed through discussion. Water can be decomposed by passing direct current through it. The decomposed water forms two gasses, hydrogen and oxygen. The ratio of the two gasses will be two parts hydrogen to one part oxygen. This is the reason that water is given the chemical formula of H_2O. Sulfuric acid is used as the electrolyte because pure water will not conduct electricity. Hydrogen ions come from the sulfuric acid. At the positive electrode, the sulfite ion and a water molecule combine with the loss of electrons to produce oxygen and another sulfuric acid molecule. Thus there is no loss in sulfuric acid, and the net result is that a molecule of water is used and hydrogen and oxygen are produced.

Demonstration: Water Pressure

Objective. To show how water pressure is related to the depth of the water.

Materials. A manometer tube mounted on a white card and containing a colored solution (potassium permanganate); a large glass battery jar nearly filled with water; a three foot length of rubber tubing; a short thistle tube with a piece of a toy balloon stretched across the mouth to act as a diaphragm; a tall fruit juice can with five holes the size of a small nail at two inch intervals up the side of the can; match sticks.

Method. Connect one end of the rubber tubing to the manometer and the other end to the thistle tube. Adjust the level of the liquid in the manometer. With your thumb, apply pressure to the rubber diaphragm and note the change in the position of the liquid in the manometer. Now lower the thistle tube in the battery jar, noting the position of the liquid in the manometer as the thistle tube is pushed more deeply into the liquid. Next, turn the thistle tube in all directions in the water taking special care to keep the center of the diaphragm at the same depth while making these direction changes (up, down, sideways). With short pieces of match sticks plugging the holes in the holes in the fruit juice can, fill the can with water. Hold the can over the sink. With the help of a student, pull all the match sticks from the holes simultaneously.

Observation. As the diaphragm on the thistle tube is forced more deeply into the water, the liquid in the manometer is pushed higher in the tube, indicating an increase of water pressure. As the diaphragm is placed in different positions (upside down, right side up and sideways) there is no apparent change in the manometer reading. With the removal of the match sticks from the small holes in the can comes a surge of water. The water from the bottom hole is forced out with a greater force than from the other openings. The hole at the top has only a trickle of water coming through, with each descending hole having an increased rate of flow.

Conclusion or generalization to be developed through discussion. Water pressure increases with increased depth. At any given depth, the pressure is equal in all directions.

Demonstration: Hard and Soft Water

Objective. To determine what is meant by "hard" and "soft" water.

<u>Materials</u>. 10 test tubes; one glass tube 6" long; distilled water; lime water; soap solution; tap water; calcium sulfate; sodium carbonate (washing soda).

<u>Method</u>. To a test tube one-half full of distilled water, add four drops of soap solution. Repeat, using tap water. Compare the amount of suds formed on each of the samples of water. Blow exhaled air into a test tube three-fourths full of lime water. Continue this bubbling action into the lime water until the white precipitate that forms disappears. The carbon dioxide from your breath causes a chemical reaction, changing the calcium hydroxide in the lime water to calcium bicarbonate, a substance often found in a type of water called temporary hard water.

If the solution is not clear, filter it. Divide this temporary hard water and add four drops of soap. Shake vigorously. You will note that no suds form, but there is a scum over the top of the water. This precipitate is a calcium soap compound.

Continue to add soap, drop by drop, until a suds forms. Note the number of drops of soap needed to form suds. Heat very gently the second portion of temporary hard water. Add four drops of soap solution and shake vigorously. If suds do not appear, add soap drop by drop until they do appear. To the third portion of temporary hard water add lime water, drop by drop, until no more precipitate forms.

Filter and test the liquid with a few drops of soap solution. To a test tube one-half full of calcium sulfate solution add four drops of soap solution. Shake vigrously. Note any suds. The water containing dissolved calcium suflfate is called permanent hard water. Boil some calcium sulfate solution for two or three minutes. Add a few drops of soap to note any difference in the amount of soap needed to produce suds. To a test tube half filled with a permanent hard water add one-fourth of a test tube of sodium carbonate solution, (washing soda) drop by drop. Filter and test the solution with a few drops of soap.

Observation. Distilled water produces many suds with four drops of soap solution (the number of drops needed to produce these suds may vary depending on the concentration of the soap solution). Tap water produced no suds, only a scum of precipitated minerals. Calcium bicarbonate solution is called temporary hard water. When soap is added to temporary hard water that has not been boiled, no suds are produced, only a scum of precipitated minerals. After heating temporary hard water a suds was produced when four drops of soap were added. When lime water is added to temporary hard water an insoluble precipitate forms that will settle to the bottom of the test tube. When soap is added to this solution, suds are formed. Calcium sulfate causes permanent hard water.

Twenty-one drops of soap had to be added before all the mineral was precipitated and suds were allowed to form. Heating the calcium sulfate solution did not decrease its hardness. Adding washing soda did increase the hardness of permanently hard water.

Conclusion and generalization that should be developed through discussion following this demonstration. Distilled water (water with the minerals removed) is soft water and will allow suds to be produced quite easily. Tap water in Des Moines is hard water. Temporary hard water contains some metal bicarbonate. Temporary hard water can be softened by boiling. Permanent hard water often contains some sulfate compound. Permanent hard water cannot be softened by boiling. Permanent hard water can be softened by adding washing soda (sodium carbonate).

Demonstration: Archimedes Principle

Objective. To understand why some objects float in water while other objects sink.

Materials. Ten pound spring scales; large container, such as a dishpan; small bucket with bail; string; large wooden block; large, non-porous rock.

Method. Weigh large non-porous rock. Place bucket in dishpan and fill the bucket brim full of water. Now hang the stone from the spring scales and weigh stone when it is immersed in water. The weight is now found to be less than before, due to the buoyant effect of the water. The stone has caused a quantity of the water, equal to the volume of the stone, to spill from the bucket into the dish pan. Remove the bucket and weigh the dishpan with its contained water. Pour out the water and weigh the dishpan alone. Weigh the large wooden block. Again, place the bucket in the dishpan and fill the bucket brim full. Carefully float the block of wood in the bucket of water. Collect the overflow water from the bucket in the dishpan. Weigh the dishpan and its contained water.

Observation. The difference in the weight of real weight of the stone and its weight when immersed in water equals the weight of the water in the dishpan. The weight of the water in the dishpan equals the weight of the block of wood.

Conclusion and generalization that should be developed through discussion following demonstration. A body, when placed in water, is buoyed up by a force equal to the weight of the displaced fluid. If this force is less than the weight of the object, the object will sink. If this force is equal to the weight of the object, the object will float.

III. SOUND

The term sound is used in two senses: one, it signifies the sensation of hearing, and two, it signifies the vibratory motion which gives rise to that sensation.

The sound that reaches our ears provides us with an immense amount of information. Sound makes us aware of the voices of friends, the rustling of leaves, the crash of thunder, and the clatter of an approaching train. Yet, the source of all these varied sounds is simply a series of pressure changes.

A tree crashes to the ground. As it falls, it produces disturbances in the air, and these disturbances give rise to pressure waves that travel out in all directions. Some of these waves strike our eardrum and set up vibrations that are recorded in the brain. It is through this chain of events that we hear the crash of the tree.

Pressure waves are formed as a result of a vibrating object. As the object vibrates, it brings about a compression. That is, it pushes aside and crowds together the molecules of air in the immediate vicinity. In this way, a repeated series of compression waves will be formed as the object continues to vibrate.

It is necessary to acquire several basic understandings before a student is able to have a working knowledge of the science of sound. These understandings would include: How sound is produced and transmitted; The law of vibrating strings; The velocity of sound; Characteristics of sound. The following demonstrations have been included in this resource book because they help develop these understandings.

Demonstration: How Sound Is Produced and Transmitted

Objective. To demonstrate how sounds can be produced and how this sound is transmitted to our ears.

Materials. A tuning fork; a rubber mallet (this can be a one-hole stopper on a pencil); six test tubes; a glass of water; a yard stick; an electric bell; a bell jar (with hole in top for electrode); a vacuum pump.

Method. Strike the tuning fork with the mallet and hold it so the class may hear it. This can be done by placing the base of the fork on the laboratory desk. The resonance produced will intensify the sound. Have a student hold the glass of water in his left hand and hold it up against the blackboard at such a heighth that all students can see. The instructor should strike the tuning fork with the mallet and thrust the vibrating prongs of the fork into the container of water. The vibrating prongs will cause the water to spray up against the blackboard, thus showing all the students evidence of vibrations.

Now take the yardstick and hold its flat side firmly on the table with about one foot projecting over its edge. Pull up on the free end of the stick and release it. Push the stick out another six inches and repeat the action. As the yardstick is released, it will vibrate in such a manner as to be seen and heard by all.

Next, blow your breath with high velocity across the mouth of a test tube. Note the sound. Then pour water into each of three test tubes so that one is one-fourth full, one one-half full and one three-fourths full. Now blow across the top of each tube as before. Note the results.

Place the electric bell in the bell jar and connect it to the battery. Note the sound. Now, pump the air from the bell jar and note the sound.

Observation. The tuning fork was caused to vibrate when struck with the rubber mallet, thus producing a sound. The spray of water formed when the tuning fork was thrust into the water is clear evidence of its rapid vibration.

The yard stick is limber enough to vibrate back and forth with ease when one end is held firmly against the table top. Students can easily note the difference in the sound produced. When one foot of the yard stick is over the table top, a very high pitched sound is produced. As the free end becomes longer, the sound emitted becomes progressively lower in pitch.

As one blows across the top of the test tubes the air within the tube is caused to vibrate, thus producing an audible sound. As the length of the vibrating column of air decreases, the air vibrates with greater rapidity, producing a high pitched sound.

As the bell rings in the bell jar containing air the sound can be heard in all parts of the room. As the air is removed, the sound becomes weaker and weaker until there is no sound at all.

Conclusion or generalization that should be developed through discussion. Sound waves are produced when an object is vibrating. The greater the rate of vibration, the higher the pitch of the sound. Sound waves cannot be transmitted through a vacuum.

Demonstration: Vibrating Strings

Objective. To demonstrate how the factors of length, tension and diameter affect the pitch of a vibrating string.

Materials. A four foot length of number 6 piano wire; a four foot length of number 10 piano wire; a three foot length of wood 2" x 4"; two triangular blocks of wood; a weight holder; four 500 gram disk-shaped weights.

Method. Stretch a number 6 piano wire across two triangular blocks and tune it in unison with a "C" tuning fork (256 vibrations per second) by changing the distance between the two triangular blocks of wood. This, of course, has the effect of shortening the wire, for only this section will be allowed to vibrate as it is plucked. Measure this distance and write it on the blackboard for all to see.

Using a "G" tuning fork, change the position of the triangular block until the string vibrates in unison with this fork. Make a comparison of the two lengths of wire and the pitch produced each time.

Throughout this part of the demonstration, make sure that the tension on the wire is unchanged. This can be insured by leaving the same amount of weight on the hanger throughout this part of the demonstration.

Now stretch a number 6 piano wire across the two triangular blocks of wood and tune it in unison with a "C" tuning fork by adding weights to the hanger. Measure the length of the vibrating section of wire between the two triangular blocks of wood. Now add an additional amount of weight to the hanger until the string vibrates in unison with a "G" tuning fork. Note the effect of the pitch of the vibrating wire as the tension is increased on the wire.

Remove this piece of number 6 piano wire, and replace it with a four foot length of number 10 piano wire. Adjust the position of the triangular blocks and the amount of tension on this new wire so they are identical to the length and tension used on the number 6 piano wire in the first part of this demonstration. Compare the pitch produced with this wire and the "C" tuning fork. How does the diameter of this wire seem to affect its rate of vibration as evidenced by the change in pitch?

Observation. The length of the wire must be shortened in order to change its rate of vibration from C to G. More weight must be added to the wire to change its pitch from C to G. With the same length and tension, the number 10 piano wire produces a higher pitched sound than the number 6 piano wire.

Conclusion. The shorter the length of vibrating wire, the higher the pitch. The pitch of a vibrating wire increases with increased tension. The pitch produced by a vibrating wire increases as the diameter is decreased.

Demonstration: Velocity of Sound

Objective. To determine the velocity of sound.

Materials. Tuning forks of known frequency ("C" fork at 256 V.P.S. and "G" fork at 512 V.P.S.); glass tube 1.5" in diameter and 16" long; a tall glass graduated cylinder; yard stick; tuning fork mallet.

Method. Resonance occurs when the natural vibration rates of two objects are the same. The air column in a closed glass tube produces its best resonance when it is one-fourth as long as the sound wave.

Fill the graduated cylinder nearly full of water and insert a glass tube. As you raise or lower this tube you change the length of the air column in the tube. Strike the prongs of the "C" tuning fork and hold the fork near the mouth of the tube. Move the tube until the sound of the fork becomes as loud as possible. Measure the length of the air column in the tube at this position. This is the resonant length of the tube.

Repeat, using the 512 V.P.S. fork. Compute the tube's resonant length and record on the blackboard where all may see. (The sound wave travels four times the length of the tube during one complete vibration, therefore the length of the air column is one-fourth the wave length.)

Compute the velocity of sound for room temperature. Use the equation velocity equals frequency times the wave length, remembering the wave length equals four times the length of the air column.

Observation. The length of the resonance tube for the 256 V.P.S. tuning fork is thirteen inches. Therefore, the wave length would be 52 inches. The length of the resonance tube for the 512 V.P.S. tuning fork is 6.5 inches, and the wave length would be 26 inches.

Conclusion. The velocity at room temperature for the 256 V.P.S. tuning fork would be: $V = 256 \times \frac{52"}{12"}$, or, 1,120 feet per second. The velocity at room temperature for the 512 V.P.S. tuning fork would be $V = 512 \times \frac{26"}{12"}$, or 1,120 feet per second.

Demonstration: Sound Waves

Objective. To demonstrate the difference between a transverse wave and a longitudinal wave.

Material. A long coiled spring painted white (such as a slinky); eight croquet balls painted white: a shallow V-shaped trough to hold the croquet balls.

Method. Suspend and fasten the ends of a long coiled spring to the ends of a laboratory demonstration desk. Pluck the spring at right angles to its length. Compress several turns of the spring and release them quickly. Place seven croquet balls near one end of the shallow trough, and roll the eighth ball with some force toward them from the other end of the trough.

Observation. When the spring is plucked at right angles to its length, a wave is set up which travels along the spring from one end to the other and then returns by reflection. As the waves advance, there is actually little or no forward movement of the coils in the spring. This type of wave is described as a transverse wave.

When several turns of the coiled spring were compressed and then released, a wave was formed in which the wire is made to vibrate in the same direction as the path along which the wave is traveling. This is described as a longitudinal wave.

As one rolls a single croquet ball toward the remaining seven, the force of the impact is communicated to each of the seven balls until the last ball is reached. This ball rolls out of position away from the remaining balls.

Conclusion. Water waves and light waves are transverse waves. These waves vibrate at right angles to the direction in which the wave is traveling. Sound waves are longitudinal waves, and they vibrate in the same direction as the wave is traveling.

When the croquet ball is rolled so that it strikes one end of the row of balls head on, the ball at the other end of the row moves away at a speed equal to that of the ball rolled. Each ball has been disturbed. This disturbance has passed along the entire line of balls, but no ball has moved from one end of the line to the other. This is also true of sound waves. The compression wave does not actually move a great distance; its energy is imparted to the next compression, and thus is transmitted from molecule to molecule just as was demonstrated with the croquet ball.

IV. SOURCES AND CONTROL OF HEAT

Although man may have happened upon the use and control of fire accidentally through volcanic eruption or lightning-produced fires, he has certainly come to realize that heat energy is a valuable asset. This form of energy not only enables man to warm his body and cook his food; it is an important source of energy for the development of a modern society.

It has only been in the last century and a half that man has known much about the nature of heat. Previous to this time, heat was thought to be weightless fluid which escaped from materials when burned. As a result of experimentation, man cast away this idea concerning heat and concluded that heat is a form of kinetic energy. This energy takes the form of vibrating molecules in a substance.

Man is particularly interested in the effects of heat on objects in his environment. This interest has enabled man to devise new methods of using and controlling heat. Such inventions as the gas furnace, the thermostat, the air conditioner, and heat insulators are a few inventions that have resulted from this interest.

Consumer scientists must understand the basic principles of heat in order to live more securely with the many inventions using this form of kinetic energy.

Demonstration: How Heat Affects Solids, Liquids and Gases

Objective. To demonstrate the effect of heat expansion on solids, liquids, and gases.

Material. 500 ml. flask; toy ballon; bunsen burner; iron wire, 100cm. long; metal weight; ring stand; 250 ml. flask; glass tubing; one-hole stopper; potassium permanganate; clamps.

Method. Suspend weighted iron wire from clamp with the weight one centimeter from the base of the ring stand. Heat the wire by moving the bunsen burner up and down the entire length of the wire. Note any change in the position of the weight.

Place a toy balloon over the mouth of a 500 ml. flask. Place the flask on the ring stand and heat uniformly on all sides. Note any change in the size of the balloon.

Place a few crystals of potassium permanganate in a 250 ml. flask and fill with water. Shake until color is uniform. Insert one-hole stopper and glass tube so that water is forced up the tube above the stopper. Place the flask on the ring stand and note the position of the colored water. Heat slowly and then strongly. Note the position of the water in the glass tube.

Observation. As the wire is heated, note that the weight soon comes to rest on the ring stand and note that as the flask is heated, the balloon is inflated and becomes much enlarged. As the flask containing the colored water is heated, the water level in the tube is seen to rise.

Conclusion. Solids, liquids and gases used in this experiment expanded when heated.

Demonstration: Kindling Temperatures

Objective. To determine the relative kindling temperatures of some common substances.

Materials. Ring stand and ring; 4" x 4" steel plate; bunsen burner; small piece of sulfur; head of match; small piece of paper; wooden splint.

Method. Place equal sized pieces of paper, wood splint, sulfur, and the head of a match on the corner of the steel plate. Place the bunsen burner so that the flames strike the center of the steel plate. Be sure each substance is equal distant from the center of the plate. Note the results.

Observation. The match head first bursts into flame, followed by the sulfur, paper and then the wood splint.

Conclusion. Different substances have different kindling temperatures. The match head had the lowest kindling temperature, followed by sulfur, paper, and wood.

Demonstration: Transfer of Heat

Objective. To demonstrate how heat is transmitted by conduction, convection, and radiation.

Materials. Ring stand and ring; bunsen burner; a one-foot length of copper, aluminum, and iron wire of equal diameter; candle; corn seeds; beaker of cold water; small bottle of ink; two small cans, one painted black and one silver; two thermometers.

Method. (1) Conduction. Attach the three wires of copper, aluminum, and iron to the ring so they will all touch at one end. With the candle, fasten four corn seeds to each wire at intervals of one inch. Place the bunsen burner flame directly under the wires at their point of meeting.

(2) Convection. Lower a small bottle of ink into the cold water along the side of the beaker. Set the

bunsen burner so the flame strikes near the bottom of the ink container. Heat for several minutes.

(3) Radiation. Place an equal quantity of water in each of two small cans. The water should be the same temperature. Place a thermometer in each can and put them in the sun. Have a student read the initial temperature, and then the temperature at 5-minute intervals for 45 minutes.

Observation. (1) As the wires are heated, the heat will be conducted along each wire until the wire reaches the melting point of the paraffin. When this occurs, the corn seeds will drop from the wire. The order of highest conductivity of the wires will be copper, aluminum and then iron.

(2) As the small bottle of ink is heated, the ink expands, rises to the surface of the water, travels across the surface and then descends on the opposite side.

(3) As the radiant heat from the sun strikes the cans, they are warmed. Most of the radiant heat that strikes the silver can is reflected, and that which strikes the black can is absorbed. This is readily observed as the temperature in the black can becomes higher than that in the silver can.

Conclusion. (1) Conduction. When heat travels from one molecule to another by molecular collision, the process is called conduction. Most solids, particularly metals, are good conductors of heat. On the other hand, solids like glass brick and wood, which are not metals, are very poor conductors of heat. Liquids and gases are also poor conductors of heat.

(2) Convection. If a gas or a liquid is heated, it will expand and decrease in weight per unit volume. This will cause the liquid or gas to rise. This change in position, due to decreased weight, is called convection. The ink used in this demonstration rose to the surface because of convection. The ink then lowered on the opposite side because it had become cooled, contracted and became heavier than the water.

(3) Radiation. The sun or other hot bodies give or radiate energy in the form of waves. These tiny waves travel through space without the aid of molecules of matter. Radiant energy becomes heat only when it is absorbed by matter and causes the motion of molecules. This is what happened in this demonstration. Both cans absorbed these radiant rays and transformed them into heat. The black can absorbed more of these rays than did the white can causing the water in it to be warmed more quickly than the water in the shiny can.

Demonstration: Cooling Through Evaporation

Objective. To demonstrate that the evaporation of a subatance requires heat.

Materials. Large cork; eye dropper; water; watch glass; ether; vacuum pump; bell jar.

Method. Place a large cork on the stage of the vacuum pump, and add a drop of water in the center of the flat surface of the cork. The watch glass is now to be placed on this drop of water. Fill the watch glass with ether and cover with the bell jar. Remove the air from within the bell jar.

Observation. As the air is removed from the bell jar, the ether can be seen to boil and evaporate away. Allow the air to re-enter the bell jar and remove it from the stage of the vacuum pump. The watch glass will be frozen to the cork.

Conclusion. To evaporate a liquid requires heat. The heat needed for the evaporation of the ether comes from the water. This heat removal causes the water to freeze.

V. OUR USE AND CONTROL OF LIGHT

Most of the things we know and experience come first through our ability to see. Light is a form of energy, just as are heat, magnetism, and electricity. It will do work for us if properly controlled.

No one seems to know for sure just what light is, but much is known concerning the laws and principles that control it. Through the application of these scientific principles we are able to improve and extend our vision. Now we can see the invisible world of microorganisms and study distant planets and stars. We take pictures in color and transmit them through space by the marvel of television.

It is the responsibility of the modern high school to impart these known principles to the science consumer of tomorrow.

Demonstration: How Light Travels

Objective. To demonstrate that light travels in straight lines.

Materials. Three six-inch squares of quarter-inch plywood with a 1/8 inch hole drilled through the center of each large flat surface; three pieces of 1" x 2" wood, six inches long, each of which should be tacked to the edge of each 6" x 6" piece of plywood to form a base, thus enabling them to stand upright; a 1" x 8" board three feet long on which a center line has been drawn that extends the length of the board; two small candles.

Method. Light a candle and place it near the end of the 1" x 8" board over the center line you have drawn. Place one of the upright blocks of wood a foot from the candle so you can see the candle flame through the 1/8" hole. Next, place a second upright piece 18" away from the candle on the same side as the original upright piece. The 1/8" hole in this second piece should be one inch to the right of the center line. Have a student look through this hole to see if he can see the candle flame. Have the student announce to the class where it must be placed. Now set up the third upright a foot from the second one and directly over the center line. Have the student look to see if he can see the candle flame. Move anyone of the three upright boards and have the student announce whether or not he can see the candle flame.

Observation. The only time that the candle flame can be observed is when the 1/8" holes are directly in line.

Conclusion. Light travels in straight lines.

Demonstration: Light Refraction

Objective. To demonstrate the behavior of light as it passes from a medium in which light has a high velocity into a medium in which light travels more slowly.

Materials. A rectangular glass bottle; water; small quantity of starch; flashlight; a smoke box. (A smoke box for this demonstration and the following demonstration should be built two feet high, two feet wide, and four inches deep. The front of the box should be fitted with a piece of window glass. On the inside of the back, opposite the window glass, paste a circle of paper which has been divided into degree markings which can be seen from all parts of the room.)

Method. Arrange a flash light to produce a beam of light inside the smoke box. Fill the large rectangular bottle with water and add a small quantity of starch to make the water cloudy. Cork the bottle and rest it on two support pins which have been driven through the paper circle on the horizontal axis. Fill the box with smoke by burning an incense candle. Direct the beam of light at an oblique angle so that it strikes the rectangular bottle.

Observation. Observe how the path of light in the bottle is affected. We may call the incoming beam of light the incident ray. The angle between this beam and the normal to the surface is the angle of incidence. The light beam, after bending in the bottle, is called the refracted ray, and the angle that it makes with the normal is the angle of refraction.

Conclusion. When a light ray passes obliguely from one medium to another the ray will bend toward the normal if it decreases its velocity, and away from the normal if the velocity of the light is increased.

Demonstration: Reflection of Light

Objective. To demonstrate that the angle of incidence equals the angle of reflection.

Materials. Smoke box; flashlight; mirror; punk; and matches.

Method. Two nails should be driven through the paper circle that is on the inside back of the box opposite the window glass. The nails should be placed on the horizontal axis. Support a mirror on these nails. In the top of the box cut a narrow slit one inch long in the center of the four inch dimension at right angles to the glass front. This slit should be six inches from the right end of the box.

Project a flashlight to produce a beam of light inside the box with smoke by burning a small piece of punk or an incense candle inside the box.

Observation. The path of light beam can be seen clearly as the smoke particles in its path are illuminated. Note the angle of the incident beam and the reflected beam on the degree circle in the box.

Conclusion. The angle of incidence equals the angle of reflection.

Demonstration: Law of Illumination

Objective. To demonstrate how the intensity of illumination is affected by the distance from a light source.

Material. A 25 watt light source and a 100 watt light source; a small photoelectric cell; a large demonstration type galvanometer; a resistance box; a yard stick; five feet of #18 gauge bell wire.

Method. Connect a 25 watt light source to a standard 110 volt circuit. Connect in series the galvanometer, the resistance box and the photoelectric cell. Place the photoelectric cell exactly two feet from the 25 watt lamp with all the resistance plugs pulled in the resistance box. This will insure against having too much current in the galvanometer circuit. Carefully reduce the amount of resistance in the circuit. Continue to reduce the resistance until the galvanometer needle registers its full scale. Note on the blackboard what this reading is and bring to the attention of the students the position of the galvanometer needle. No further change should be made in the amount of resistance in the circuit.

Now place the photoelectric cell exactly three feet from the light source. Take note of the reading on the galvanometer and the position of the needle. The photoelectric cell should now be placed four feet from the light source and again record the galvanometer reading. In a like manner repeat this operation, using the 100 watt lamp. Position the photoelectric cell again at two, three, and four feet, recording the galvonometer readings each time.

Observation. Students, of course, are quick to observe the fact that the intensity of light decreases as one moves away from a light source. They may not, however, see the mathematical relationship. This should be developed by the instructor.

Conclusion. The amount of illumination at any point varies inversely with the square of the distance between the light source and the point.

VI. ELECTRICITY AND MAGNETISM

The pupils of high school physical science need to become aware of the tremendous influence electricity has on the lives of modern man. An adequate understanding can be secured only through a study of the forces which produce or convert one type of energy to another. The main emphasis belongs on the uses of electricity.

In this unit, demonstrations will be included that will allow the student to become familiar with the laws controlling the production of electricity. Also included in this unit is a unit informing the student how to make magnets and to understand the laws controlling them.

Understanding how electricity can be transmitted and controlled in simple electric circuits is of special interest to the science consumer. Nearly all uses of electricity involve the conversion of electrical energy into some other form of energy, such as heat, light or sound energy.. This useful and convenient fact warrents special attention in classroom activities.

Demonstration: Production of Electricity

Objective. To demonstrate methods of producing electricity.

Materials. Rubber comb, small bits of paper, a strip of copper four inches long and 3/4 inches wide; a zinc strip four inches long and 3/4 inches wide; three feet of #18 bell wire; galvanometer; dilute sulfuric acid; glass container; coil of bell wire; strong horseshoe magnet.

Method. (1) Comb the hair of a student whose hair is dry. Try to pick up small bits of paper with the comb. Again comb this student's hair and bring the comb near a metal faucet or radiator. Observe and listen closely.

(2) Connect an eighteen inch length of wire to the copper and zinc strips. Fasten the wire from the zinc strip to the negative pole of the galvanometer. The copper strip is to be connected to the positive pole of the galvanometer. Touch the pieces of copper and zinc together. Does the meter indicate that there is an electric current? Now dip the strips into glass containing dilute sulfuric acid. Note the position of the galvanometer.

(3) Connect the ends of a coil of flexible bell wire to the demonstration type galvanometer. Move this coil of wire between the poles of a strong horseshoe magnet. Note any position change in the needle of the galvanometer. Move the coil down. Note the direction the needle moves. Move the coil upward and note the direction of the galvanometer needle.

Observation. Electricity is produced in the rubber comb as it is rubbed in the hair of the student. This was clearly observed by the spark produced between the comb and the water faucet.

Electricity is produced when the zinc and copper electrodes are placed in the dilute sulfuric acid.

Electricity is produced as a wire is passed between the poles of a horseshoe magnet. As the lines of force between the two poles are broken, a current of electricity is induced into the wire.

Conclusion. Electricity can be produced by friction, by chemical action or mechanically by breaking the lines of force of a magnet.

Demonstration: Magnets

Objective. To demonstrate the ways of producing magnetism. To demonstrate the law of the poles.

Material. Two strong bar magnets; a five-inch section of a hack saw blade; thread; a suspension bar; a large spike nail; 24" of #18 guage bell wire; a dry cell battery; iron filings.

Method. Test the hack saw blade by placing it in iron filings to show that it has no magnetism. Stroke the hack saw blade with the north pole of a bar magnet beginning at one end and continuing to the opposite end. Return to the starting position through the air. Repeat twelve to fifteen times. Again test the magnetism of the hack saw blade by placing it in the same iron filings. Test the magnetism of the spike nail by placing it in iron filings. Now wrap forty turns of the bell wire around the spike. Connect the ends of this coil of wire to the terminals of the dry cell. Return the nail to the iron filings while current flows through the encircling wire. Observe.

Suspend a bar magnet from the suspension bar by means of the thread. Bring the north pole of the second bar magnet near the north pole of the suspended magnet. Note the action. Now bring the south pole of the second magnet near the north pole of the suspended magnet. Note the action.

Observation. The hack saw exhibited no magnetism, however, when it was rubbed with the permanent magnet it definitely became magnetized, for it attracted many iron filings. The nail exhibited no magnetic properties, however, as current flowed through the coil it readily picked up many iron filings.

As the north end of the suspended magnet came near the north end of the second magnet, it turned away as if trying to avoid it.

As the north end of the suspended magnet came near the south end of the second magnet it turned toward it, as if it were attracted. The two magnets then stuck to one another.

Conclusion. One can make a magnet by rubbing a piece of hard steel with a permanent magnet, or by passing a current of electricity through a coil of wire around a piece of soft iron core.

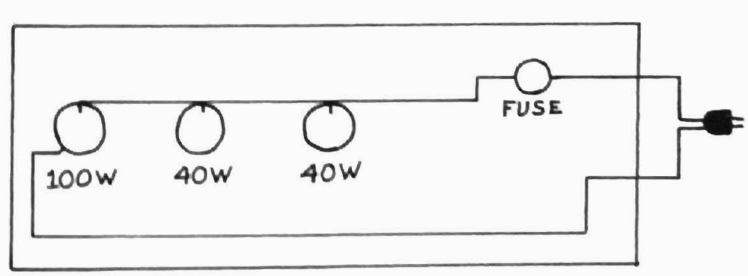
We may state the law of the poles as follows: like poles repel; unlike poles attract.

Demonstration: Simple Electric Circuits

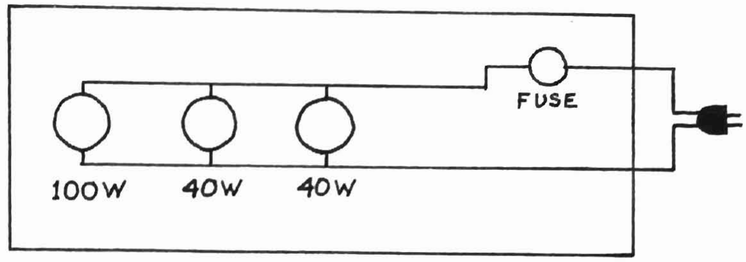
Objective. To demonstrate how series and parallel circuits differ.

Material. Four 110-volt electrical outlet sockets; a tumbler switch; two 40-watt bulbs; one 100-watt bulb; a 15 amp. fuse; a pine board two feet long and eight inches wide; eight half inch screws; one burned out bulb.

Method.



SERIES CIRCUIT



PARALLEL CIRCUIT

(1) Connect the apparatus as shown for a series circuit, using two forty-watt and one-100 watt bulbs. The fuse will act as a safety precaution in case some error is made. Close the switch. Note the appearance of the bulbs. Note which bulbs are brighter. Unscrew one bulb and note what happens. Unscrew one bulb and replace it with a burned out bulb, and observe what happens.

(2) Connect the three sockets in parallel as shown in the diagram, using two forty-watt bulbs and one 100-watt bulb. Close the switch, noting the appearance of the bulbs. Observe which bulbs are brightest. Unscrew one bulb and observe what happens. Unscrew one bulb and replace it with the burned out bulb and observe what happens.

Observation. (1) In series all the bulbs will be much dimmer than normal, and the 100-watt bulb will be the dimmest of all. As one bulb is unscrewed, all bulbs go out. As one good bulb is replaced with a burned out bulb, all lamps will go out.

(2) In parallel wiring all lights will have their normal brightness. As one bulb is unscrewed, the remaining bulbs will continue to be lighted. As a good bulb is replaced by a bad bulb, the remaining bulbs will remain lighted.

Conclusion. Parallel circuits have the advantage of giving full power to all appliances in the circuit. As one appliance is turned off, the remaining appliances continue to operate normally. This is not true of a series circuit.

Demonstration: Heating Effects of Electricity

Objective. (1) To demonstrate the relationship between the heating effect of an electric circuit and the resistance in the wire. (II) To demonstrate that the heating effect increases with the number of amperes of current flowing in the circuit.

Material. Two binding posts; three dry cells; wooden block; five inches of #30 copper wire; five inches of #30 German silver wire; ten inches of #30 copper wire; demonstration type ammeter.

Method. Determine whether the copper or the German silver wire has the greater amount of electrical resistance. This can be determined by placing the copper wire in series with a dry cell and the ammeter. Note the amperes of current. Connect the German silver wire in series with this same dry cell, and determine the ampere flow. As the resistance in a circuit increases, the rate of flow, or amperes, will decrease. This will show that the German silver has a higher electrical resistance.

Part I. Mount the two binding posts eight inches apart on the block of wood. Splice the five inch length of copper wire to the five inch length of German silver wire, and connect in series to the two binding posts. This series combination will insure that the same amount of current will flow through each wire.

Part II. Pass the current from a single dry cell through the ammeter and the ten inch length of #30 copper wire. Now pass the current from two and then three dry cells, through the ammeter, and through the ten inch length of copper wire. Observe the difference in the temperature of the wire.

<u>Observation</u>. Part I. The copper wire will be warm, whereas the German silver wire will become red hot and will then melt.

Part II. As the current from one dry cell passes through the ten inch length of copper wire it becomes warmed. The current from two dry cells causes it to glow red hot.

With the addition of the third dry cell, the temperature reaches the melting temperature of copper, and the wire will then break.

Conclusion. The heating effect of an electric current is greater in a wire which has the greatest resistance. We could conclude that increased friction causes more heat to be developed. We also find that the heating effect increases with an increased amount of current flowing in the circuit.

VII. THE PLACE OUR EARTH OCCUPIES AMONG THE HEAVENLY BODIES

As surely as night follows day the inquiring minds of high school students will turn to the facinating questions concerning the Earth and the heavenly bodies of our universe.

As a result of additional probes into the celestrial sphere new information will be available, thus making this topic new and refreshing to students. It is, therefore, our responsibility to make sure that these future "space explorers" are well grounded in basic concepts concerning this topic.

A sample of such understandings would include:

1. Learn that the sun is the center of a great solar system, of which the earth is but a small part.

2. Learn to recognize the main constellations of our solar system.
3. Understand the change of position of the earth with respect to the sun, moon and other planets.
4. Become familiar with the natural events of the solar system, such as eclipses, comets, meteors, tides and seasons.
5. Understand the principle of astronomical instruments.
6. Understand the principle of determining astronomical distances.
7. Understand the units of time as related to our sidereal system.
8. Understand the principles for determining latitude and longitude on the earth's surface.
9. Understand the light year as a unit of measure.
10. Recognize prominent stars in summer and winter skies.

With this backlog of understandings, newly gathered information will be readily incorporated into the students' field of experience.

Demonstration: Cause of the Seasons

Objective. To demonstrate the causes of seasons.

Material. Large globe; cardboard with parallel lines one inch apart horizontally on the page. One side of the cardboard should be cut in an arc so it will fit snugly against the globe; ring stand and clamp; flashlight; pencil; colored chalk; scissors; 4" x 5" cardboard with one-inch square hole in the center.

Method. Draw with the colored chalk the outline of the tropic of cancer, the tropic of capricorn and equator on the globe. Color with chalk the position of Des Moines, Iowa, and a spot four inches north of Des Moines on the globe. Hold the globe with the axis in a vertical position. Mount the flashlight to the stand so it points directly at the equator. Rotate the globe and hold the cardboard in a vertical position so that the curved edge passes over the surface of the globe. Have the students relate to you the result if the sun revolved around the earth with the axis in this position.

Now tilt the globe so that the north pole is tilted away from the flashlight at the angle of 23½ degrees from the vertical. Adjust the flashlight so its beam falls directly on the tropic of capricorn. Hold the cardboard as before, and place the center line on the tropic of capricorn. Assume that each space in the cardboard between any two lines represents ten light rays from the sun. Count the light rays that would strike that part of the globe between the two chalk marks (Des Moines and a position in Canada four inches north of Des Moines on the globe.) Note also the angle of the rays that strike our area when the flashlight is over the tropic of capricorn.

Now move the globe in a counter-clockwise direction one quarter of a revolution around the flashlight, keeping the axis pointing toward the north star. Turn the flash-light so its beam falls on the equator. What date does this position represent? Hold the center line on the equator. Count the light rays that would strike that part of the globe between the two chalk marks. Note also the slant of the rays that strike Des Moines for this date.

Move the globe another quarter of a revolution and rotate the flashlight. Be sure the axis still points to the north star. Turn the flashlight. Where does the beam now fall? What date is this? Count the light rays that would strike the area between Des Moines and four inches north of Des Moines on the globe. Note also the slant of the rays that would strike the Des Moines area.

Next, move the globe another quarter of a revolution and rotate the flashlight. Where does the beam fall? What date does this represent? Which previous position gave the same results?

Observation. The three causes we discovered that are responsible for the variation in the heat and light rays during the year are: (1) the angle that the rays strike the Earth; (2) the number of rays that strike the Earth; (3) the intensity of the rays that strike the Earth.

Conclusion. The changes of seasons result from varying amounts of heat received by areas of the Earth's surface as the Earth revolves about the sun with its axis always pointing toward the north star.

Demonstration: Constellations

Objective. To teach students to recognize the common constellations.

Materials. A slide projector; small pieces of black construction paper; blackboard chalk.

Method. Cut pieces of black construction paper to fit the slide holder of the slide projector. Punch small holes in the shape of the constellations being illustrated. Each hole will represent a star in the constellation. The holes in the paper will act as a light source when placed in the projector. These spots of light can then be projected onto the blackboard. Students can connect these spots of light with chalk in order to better visualize the constellations.

Conclusion. Test the students in a practical way by projecting a series of ten constellations on the blackboard and have the students recall them for an examination.

Demonstration: Telescopes

Objective. To demonstrate how a simple refracting telescope can be constructed.

Materials. Yard stick; 2 lens holders; one double convex lens with a focal length of about 12 inches; one double convex lens with a focal length of about two inches; a small candle; a cardboard screen.

Method. Clamp the lens in the lens holder and place the holder on the yard stick at the 18" mark. Place the cardboard screen near the six inch mark on the yard stick. Point the meter stick toward some distant object. Move the screen along the yard stick until a position is found where the image of the distant object is as nearly in focus as possible. The distance between the lens and the screen is the focal length of the lens. In the same way, determine the focal length of the second lens. Add the focal length of the second lens, i.e., 12" plus 6" equals 18". Mount the two lenses on the yard stick 18" apart and turn the meter stick to the window and observe.

Observation. One will note that the lens of the shorter focal length will magnify the real image produced by the lens with the longer focal length.

Conclusion. An object can be magnified by placing two lenses between you and the object. The lenses must be separated from each other with a distance equal to the sum of the two focal lengths. This technique is utilized in constructing refracting telescopes.

Demonstration: Color Identification of Elements

Objective. To demonstrate the principle used by astronomers to determine the composition of stars.

Material. Clean platinum or nicrome wire; salts of calcium, sodium, copper, cobalt, potassium; distilled water; sandpaper; bunsen burner.

Method. Moisten the clean wire in distilled water and dip it into the calcium salt. Hold the wire on which the sodium salt is clinging in the edge of the hot bunsen burner flame. Observe the color. Clean the wire, and proceed in a like manner using each of the remaining salts.

Observation. The calcium salt produces a brick red color; sodium, yellow; pale violet; copper, green; cobalt, scarlet.

Conclusion and generalization to be developed through class discussion. Each of the elements gives off its own combinations of color when heated sufficiently. Astronomers have made use of this principle in identifying the composition of heavenly bodies. This is possible because of an instrument called a spectroscope, by which the composition of unknown objects can be determined by their color. Because the sun and stars are hot, their composition can be determined.

VIII. WEATHER

The weather is undoubtedly the most constant subject of conversation. Either man is so unimaginative that he has difficulty expressing original thoughts or he is consciously or unconsciously concerned about his own well being and comfort in his ever-changing environment, the atmosphere.

The old cliche that everyone talks about the weather, but no one does anything about it may not always be true. New frontiers are opening for the scientist of the future in the area of meterology. We may, perhaps, be able to control our weather environment more completely, or at least avoid costly disasters through adequate warning system.

Meterology has advanced rapidly through the use and refinement of meterological instruments. In this unit, the overall goal will be to enable students to understand principles of these measuring devices and to recognize the significance of their readings.

<u>Demonstration: Atmospheric Pressure</u>

<u>Objective</u>. To understand what affects the height of the mercury in a barometer tube.

<u>Materials</u>. Ring stand; test tube holder; test tube; 36" barometer tube; a short piece of glass tubing bent to form a right angle; a two-foot length of rubber tubing; one pound of mercury; vacuum pump, if available.

<u>Method</u>. Insert the empty barometer tube and bent glass tubing in a two-hole stopper. Adjust the position of the stopper so that the barometer tube reaches the bottom of the test tube when the stopper is pressed down tightly. Now, remove the stopper from the test tube and fill the barometer tube with mercury using a medicine dropper. Invert the test tube over the open end of the barometer tube and push the stopper into it. Invert the two tubes and support them in the test tube holder that is attached to the ring stand. Bring to the attention of the students the fact that the mercury no longer fills the 36" barometer tube. Ask why the mercury does not run out of the barometer tube.

Connect the piece of rubber tubing to the end of the bent piece of glass and draw air out of the test tube with a vacuum pump, or your mouth (Mercury is a poison, so make sure that none enters the mouth). Ask the students to explain why the level of mercury in the barometer was lowered. Allow air to return into the test tube and watch the barometer level. Blow air into the test tube and not the effect. If a vacuum pump is available, connect it to the rubber tubing and exhaust the air from the test tube.

Observation. An increase in atmospheric pressure causes the barometer level to increase. A decrease in atmospheric pressure caused the barometer level to fall.

Conclusion. Cold air and/or air with very low humidity is heavy air, and will result in increased barometric pressure. Warm air and/Or air with the high water content is light air and will result in a low barometric pressure.

Based on these understandings, therefore, weather forecasters understand that a rising barometer shows that the density of the air is increasing, a rising barometer indicates fair or clearing weather, a rapidly falling barometer indicates an approaching storm, continued high barometric pressure indicates steady, fair weather.

Demonstration: Hygrometer

Objective. To demonstrate the method of determining relative humidity.

Materials. Two Fahrenheit thermometers; five-inch strip of muslin; thread; small container of water at room temperature; small electric or a hand fan.

Method. Wrap one end of the muslin strip around the bulb of the thermometer and tie it securely with the thread. Place the other end of the muslin into the container of water. Capillary action will carry water from the container to the bulb of the thermometer. Support the thermometers in a verticle position. Read both thermometers and place these readings on the blackboard where all may see.

Place the small electric fan in front of both thermometers and turn the fan on. After a few minutes, read both thermometers and record the readings on the blackboard.

Observation. The reading of the wet bulb thermometer will be several degrees lower than the dry bulb thermometer. Observe a relative humidity table to determine the relative humidity of the air.

Conclusion. Evaporation of water causes cooling of the wet bulb. More evaporation will occur if the air is dry. This will result in much depressed wet bulb readings. Relative humidity is the ratio between the amount of vapor in the air at any one time and the amount the air could contain if it were saturated with water vapor.

Demonstration: Dew Point Apparatus

Objective. To demonstrate the method of determining the dew point.

Material. Dew point apparatus; small container of motor ether.

Method. Fill the dew point apparatus cup half full of motor ether. Replace the cork stopper containing the thermometer, the outlet tube, and the aspirator tube. The bulb of the thermometer must be completely submerged in the ether. Squeeze the aspirator bulb. The air passing over the ether will increase the rate of evaporation. Watch the surface of the cup. Read the thermometer as soon as a light film of moisture forms on the cup. Stop squeezing the aspirator. Allow the container to warm by gaining heat from the air. Note the temperature at which the moisture disappears.

Observation. The temperature when moisture forms is added to the temperature when moisture disappears.

Conclusion. The dew point is the average of these two temperatures. The temperature at which the moisture in the air begins to condense is called the dew point. Before precipitation of any kind can occur, the air must be cooled below the dew point.

Demonstration: Thermometers

Objective. To demonstrate how a thermometer shows changes in temperatures. To understand how the fixed points of a thermometer are determined.

Materials. 500 ml. flask; potassium permanganate crystals; bunsen burner; ringstand and ring; wire gauze; 18" length of glass tubing; one-hole rubber stopper; cracked ice; boiling water; strip of paper 10" long and 1" wide.

Method. Place the potassium permanganate crystals in the flask. Fill the flask with water and mix until the potassium permanganate crystals impart a uniform color to the water. Insert the eighteen inch glass tube in the rubber stopper. Press the stopper down in the mouth of the flask until the colored water shows above the cork. Connect the strip of paper on the back side of the tube to provide a white background. Mark the position of the water on this strip of paper with red ink. Place the flask over the bunsen burner and note the change in the level of the liquid in the glass tube. Allow the flask to cool and again note the position of the liquid in the tube.

Fill a glass beaker with finely cracked ice. Place the thermometer in the ice mixture so that the zero mark just shows. Watch the thermometer until it falls to its lowest temperature. Heat some water in a beaker until it boils. Place the bulb in the boiling water. Observe the mercury column and record the highest reading.

Observation. As the flask is heated, the water rises to fill more of the tube; as the flask cools the water level drops in the tube. A temperature of 32°F was recorded for the cracked ice. The thermometer rose to 212°F when placed in the boiling water.

Conclusion. The fact that liquids expand when heated and contract when cooled make it possible for them to be used in a thermometer. Mercury is often used because mercury has a high boiling point. Alcohol is used in thermometers for recording low temperatures because it has a low freezing temperature.

The fixed points used in calebrating a thermometer are the melting temperature of ice and the boiling temperature of water.

CHAPTER III

SUMMARY

Educators are constantly trying to adapt curricula content to the needs of the individual student. It has been recognized in the area of science that all students cannot benefit equally from college preparatory physics and chemistry courses. There are students who are incapable of knowing even a small degree of success in such a course. It is important that the needs of these students be met by providing a physical science course containing fundamental principles and understandings concerning their environment.

Such a course would be developed within their academic limitations, but it would enrich their lives by satisfying natural interests.

Carefully selected demonstrations augment a course of study by providing sensual experiences illustrating principles involved. They may be the missing link needed to bring abstract ideas within the students' understanding. Or, they may be the experience by which a student recalls previously learned scientific principles and apply them to his environment.

It was the purpose of this study to prepare directions for "Key Teacher Demonstrations" for a high school physical science course. A total of thirty-two demonstrations were included - four for each of the eight units of the course.

For the purposes of this project, the physical science course was divided into eight units of study. The eight units of study were:

1. The Atmosphere
2. Water and Its Uses
3. Sound
4. The Sources and Control of Heat
5. Our Use and Control of Light
6. Electricity and Magnetism
7. The Place Our Earth Occupies Among the Heavenly Bodies
8. Weather

Four demonstrations have been included for each of the eight units. Each demonstration includes: (1) The objectives of the demonstration; (2) The materials needed for the demonstration; (3) The method of presenting the demonstration; (4) The conclusions or generalizations that should be developed through discussion of the demonstration; (5) The observations students would most likely be able to make.

It is hoped that this resource booklet will provide a source of carefully selected and tested demonstrations for teachers of high school physical science.

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